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tle: THE PROBLEM OF DETERMINING THE DEFORMATION PROPERTIES OF SOIL
[K voprosy opredeleniya deformatiznykh svoistv pochv]

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[Nauchnye Trudy USKhA (Ukrainian S-Kh. Akademiya) Vyp. 100, s. 100-115, 1973.]

anslated by: Dr. William R. Gill, Soil Scientist, USDA, ARS, SR, National Tillage Machinery Laboratory, P. O. Box 792, Auburn, Alabama 36830

stract: A study was made of the deformation of the soil by a roller. The deformation properties of the soil were decreased significantly both by increase in soil bulk density and speed of movement of the roller. The modulus of deformation conversely increased with these same values.

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ywords: Rollers, deformation, bulk density, soil compaction, translations, USSR

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THE PROBLEM OF DETERMINING THE DEFORMATION PROPERTIES OF SOIL

[K voprosy opredeleniya deformatiznykh svoistv pochv]

N. P. Rozhkov, A. V. Baukov

(Scientific Reports of the Ukranian Agricultural Academy, 1973, Issue 100, pp. 100-115.)
[Nauchnye Trudy USKhA (Ukrainian S-Kh. Akademiya) Vyp. 100, s. 100-115, 1973.]

As is known, the soil is a complex elastic-viscous-plastic media [7] possessing a whole series of properties, the study of which are very difficult. Therefore, for improving the physical nature of the phenomenon occurring during the interaction of working tools of agricultural machines with the soil, we are ordinarily limited by a small number of indices of its condition.

The process of deformation of soils, as has been shown by studies of V. G. Berezantsev [2], A. S. Kushnarev [10], and other authors, consists of two phases: 1. (phase of compression/local shear); 2. phase of significant shear.

In the first phase a converging together of the particles occurs, and their density increases because of an isotropic compression. The force of the pressure during this does not exceed the limit of strength of the soil.

With a further increase of pressure a second phase starts - the plastic flow of the soil along the surface of the limiting resultant (surfaces of significant shear). The limit of load in this phase depends on the coefficient of internal friction and cohesion of the soil.

In the first phase between compacting pressures and relative deformation of compaction (elastic and residual) there exists a linear relation [1,3], characterized by the modules of deformation E_0. The magnitude of it depends on the type of soil, its moisture density and method of loading [4,5,6,8].

The large interval of the values of the modulus of deformation [4,6,8] causes the necessity of determining its magnitude for each type and condition of soil with a definite speed of loading, which must equal the speed of movement of the soil working tools.

The deformation corresponding to the first phase is made more sharply with an interaction of a smooth roller with the soil. During this it is suitably accurate to consider the speed of loading.

We will examine the scheme of interaction of the roller with the soil (Fig. 1), the pressure of which does not exceed its limit of flow.

THE PROBLEM OF DETERMINING THE DEFORMATION PROPERTIES OF SOIL

[K voprosy opredeleniya deformatsionykh svoistv pochv]

N. F. Kolkhov, A. V. Saukov

(Scientific Reports of the Ukrainian Agricultural Academy, 1973, Issue 100, pp. 100-115.)
[Nauchnye Trudy USKhA (Ukrainian S-Kh. Akademiya) Vyp. 100, s. 100-115, 1973.]

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We will examine the scheme of interaction of the roller with the soil (Fig. 1), the pressure of which does not exceed its limit of flow.

We suggest that the resulting normal reaction of the soil N is axially symmetrical for the area of contact $-a < x < a$. The hemispherical area of contact is determined from the condition, that the pressure on the operating surface P(x) must be limiting everywhere, including the edge of this area [9], i.e.

$$P = A\, a^2, \tag{1}$$

where $A = \frac{1}{2\nu}\left[f_1''(0) + f_2''(0)\right]$ = the coefficient, depending on the shape of the compressed body and the deformation properties of the soil, which is determined by the expression:

$$\nu = \frac{2}{\pi E_0}(1 + M^2), \tag{2}$$

where M = the coefficient of lateral expansion of the soil.

Substituting the value of A in equation [1] according to the compressing force we will determine the hemisphere area of contact -a:

$$a = \sqrt{2PR\nu}\ , \tag{3}$$

Where R = the radius of the roller.

From Fig. 1 it is clear, that the ratio of the depth of rut h to the width of area of contact 2a is equal to the ratio of force of resistance to rolling of the roller P_c to the compressing force P.

[Translator's Note: equation missing in the original.] (4)

Substituting the values of a and P in expression (4) we get the equation determining the value of parameter ν characterizing the deformation properties of the soil in the form:

$$\nu = \frac{Bh^2}{4P_c^2 R}\sqrt{G^2 + Pc_c^2}\ , \tag{5}$$

where B = the width of the roller;
G = the weight of the roller.

As is clear from the secured equation, determination of the deformation properties of the soil in the form of a general parameter by experimental means does not cause great difficulty. For this it is sufficient to measure the depth of the rut and the draft resistance of the roller with a consideration of the speed of its movement and the condition of the soil. Knowing the magnitude of the general indicator of deformation properties and the coefficient of lateral expansion of the soil by equation [2], it is possible to easily determine the magnitude of its modules of deformation. Therefore, the parameter ν we take in the capacity of a basic index of the condition of the soil in the time of the first phase-compaction.

The experimental equipment for determining this parameter consists of a trolley, on which were mounted the measuring apparatus (8ANCH-7m amplifier, N-105 oscellograph, power supply P-131) and the roller width B = 0.8 m, diameter D= 0.6 m and weight G = 280 kg.

The study was conducted on a heavy-loam southern black soil, the moisture of which was maintained in the range of 18-20%. The load on the roller remained constant.

The speed of movement was varied in the range from 0.3 to 1.2 m/sec with intervals of 0.3 m/sec, and the volume weight of the soil varied from 0.4 to 1.4 g/cm^3.

Each speed of movement of the roller and density of soil corresponded to 5 replications of the tests. The draft resistance of the roller measured with the help of a dynamometer link, mounted between the roller and the trolley, was recorded on the oscillograph chart and worked up by the planimeter method.

The depth of the rut was measured with an accuracy up to 0.5 mm.

The test data were worked up by the methods of mathematical statistics with the help of a "MROMIN-M" computer according to a standard program.

Results of the experimental study are presented in Fig. 2.

Since the coefficient M for soil varies in the range from 0.06 to 0.3 (8), then according to expression (2) in the range of error of the tests (9%) it is possible to determine the value of the modulus of deformation even with a maximum value of M = 0.3. With lesser values of M the accuracy of the calculations increases up to 0.5% (when M equals 0.06). The law of creation of the modulus of deformation E_0 in relation to the density of the soil and speed of movement of the roller is presented in figure 3.

The value of E_0, secured as a result of the study, is found in the range from 5 to $1.0 \cdot 10^3$ kg/cm^2, which is confirmed by experimental studies of Kh. A. Rakhmatulina [6], A. S. Kushnareva [9], S. R. Meschyana [4,5], and other authors.

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The experimental equipment for determining this parameter consists of a trolley, on which were mounted the measuring apparatus (8ANCH-7m amplifier, N-105 oscillograph, power supply P-121) and the roller width B = 0.6 m, diameter D= 0.6 m and weight G = 280 kg.

The study was conducted on a heavy-loam southern black soil, the moisture of which was maintained in the range of 18-20%. The load on the roller remained constant.

The speed of movement was varied in the range from 0.3 to 1.2 m/sec with intervals of 0.3 m/sec, and the volume weight of the soil varied from 0.4 to 1.4 g/cm^3.

Each speed of movement of the roller and density of soil corresponded to 5 replications of the tests. The draft resistance of the roller measured with the help of a dynamometer 1DRK, mounted between the roller and the trolley, was recorded on the oscillograph chart and worked up by the planimeter method.

The depth of the rut was measured with an accuracy up to 0.5 mm.

The test data were worked up by the methods of mathematical statistics with the help of a "NAIRIS-M" computer according to a standard program.

Results of the experimental study are presented in Fig. 2.

Since the coefficient M for soil varies in the range from 0.06 to 0.3 (8), then according to expression (2) in the range of error of the tests (9%) it is possible to determine the value of the modulus of deformation even with a maximum value of M = 0.3. With lesser values of M the accuracy of the calculations increases up to 0.5% (when M equals 0.06). The law of creation of the modulus of deformation E_0 in relation to the density of the soil and speed of movement of the roller is presented in figure 3.

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We suggested a method of determining the deformation properties of the soil considering the speed of loading and its condition and it can find use when establishing parameters of soil working implements.

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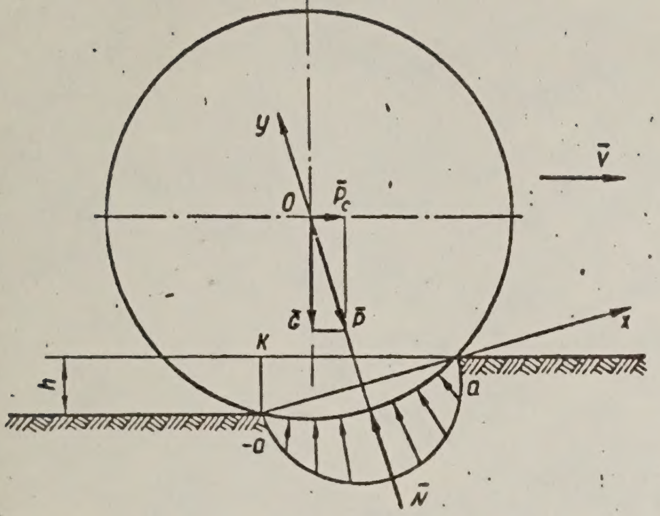

Fig. 1. Sketch of interactions of a roller with the soil.

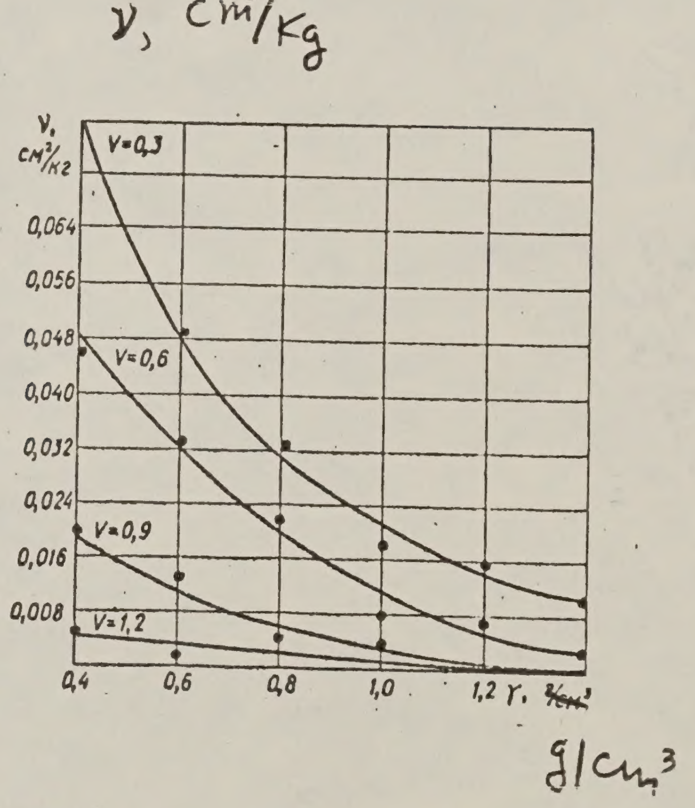

Fig. 2. General indicator of the physical-mechanical properties for a soil:
W = 20%
γ = 0.4 - 1.4 g/cm^3

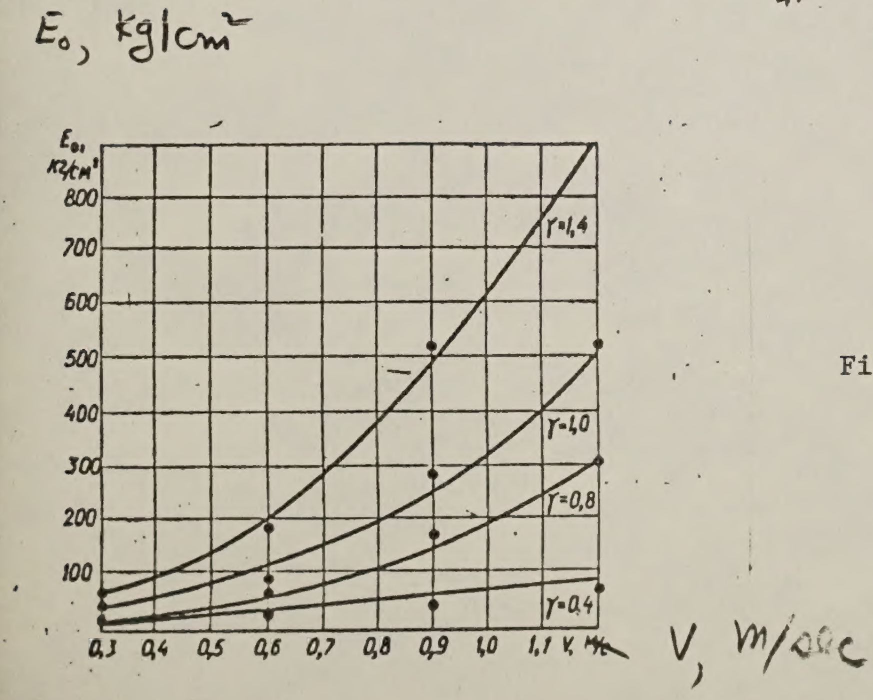

Fig. 3. Modulus of deformation for soil:
W = 20%
γ = 0.4 - 1.4 g/cm^3